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(54) Improved Dolby prologic decoder.

(57) The nucleus block of a Dolby Prologic decoder comprises two main sections: an adaptation section (21) and a matrix section (22) comprising voltage controlled amplifiers VCA. The adaptive section examines the two channel input signal to find in which direction the dominance of the sound field is located, and then generates control signals controlling the amplifiers of the matrix section. In this way we obtain the four channel output signal (R, L, C and S). According to the invention the two channel audio signal (Lt, Rt) is supplied to a block performing linear signal processing operations and processing separately the signal of both channels. The two channel output signal of the DSP block is the input signal of the matrix section (22). In this way it is possible to affect all four output channels by processing only two channels, without otherwise interfering with the function of the decoder.

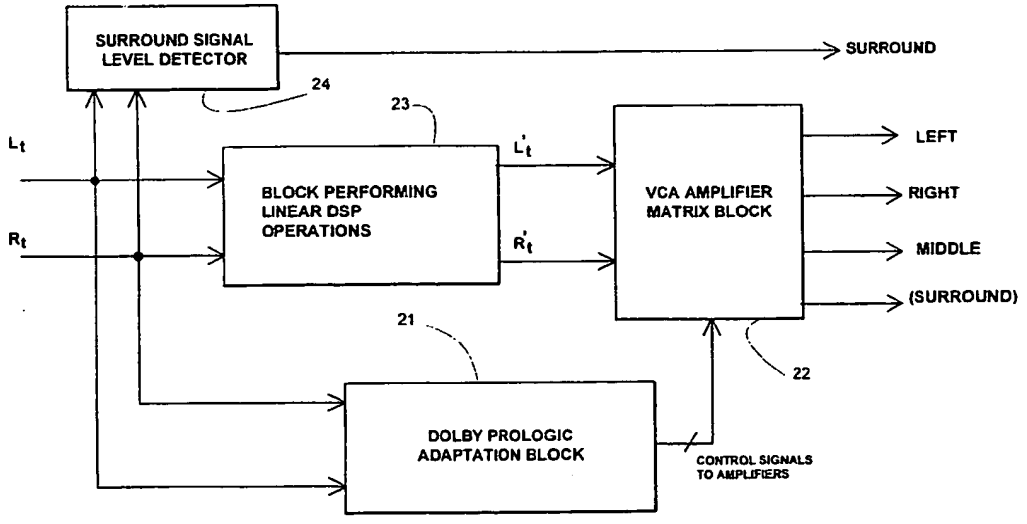

Fig. 2

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The Dolby Surround Sound system is widely used as the sound system of movies but also in video cassettes and other video recordings. The system is also extending to television applications with stereo sound. The system has four sound channels: left (L), right (R), center (C) and surround (S). They are encoded in a Dolby encoder so that L and R are transmitted in the normal way, but the C and S channels are phase encoded and included in the L and R channels. Both the center channel C and the surround channel S are divided equally into the L and R channels, but the components of the surround channel S added to the left and right channels have a phase difference of 90 degrees.

The decoder again separates the encoded four channels. In the passive decoders of the first generation the left channel L and the right channel R are supplied as such to the decoder output. These channels also contain information of the channels C and S. The center channel is detected as the sum of the the L and R channels (the surround information with opposite phases is canceled) and the S channel is detected as their difference (the center channel information with the same phase is canceled).

If the Dolby encoded sound is reproduced with conventional two channel stereo equipment the L and R sounds are localized in a normal way. The center channel C is localized in the middle of the stereo pair, and the surround channel S is not clearly localized anywhere, but is heard from an indefinite direction.

The encoder is quite simple to realize, and it comprises mainly a simple differential amplifier, a delay means and filters. The disadvantage of the encoder is that even if the difference between the main channels L and R as well as the difference between the center channel C and the surround channel S is higher than 40 dB, the difference between the adjacent channels (e.g. S and L) is only 3 dB. Therefore we have a quite small area in which the stereo pattern is good, and in which the center channel sound seems to be emitted from the middle. Also there is not a good isolation between the front and back areas, because the surround loudspeakers placed behind or on the sides of the listening space will reproduce also the difference information between the left channel L and the right channel. Therefore passive decoders cannot locate the sounds very accurately, in other words, the sound is not received from a correct, defined direction, but there is an indefinite impression of the sound.

The disadvantages of passive decoders are reduced by an active decoder. An active decoder could be conceived as a passive decoder having a processing circuit connected to it. The active decoder is called Dolby Prologic. This process examines the balance on the axes L-R and C-S. The Prologic processing tries to keep the total power at a constant level. A dominating sound is enhanced by attenuating the other channels. Thus it is possible to substantially increase the apparent channel difference.

Figure 1 shows a block diagram of the known Dolby Prologic decoder. The decoder inputs are the left channel Lt and the right channel Rt, containing the encoded center channel C and the surround channel S. The level difference of the input signals is corrected in blocks 1 and 2. The adaptive matrix block 6 of the Prologic circuit generates all channels L, R, C and S. The surround channel S is supplied to the filter 7 preventing enfolding, and through the delay means 8 adjusted by means 9, and through the low-pass filter 10 to a modified B-type Dolby noise attenuator 11. The modified Dolby B noise attenuator is developed by Dolby, and it differs from a conventional in that its noise attenuation is only half of that in the conventional attenuator. The surround signal S obtained from the attenuator output is then supplied to the output level controller 12, which also receives the signals of the left L, the right R and the center channels generated by the adaptive matrix block 6 of the Prologic circuit. At the output of the level controller we obtain all four channels as encoder output signals. The noise sequencer 3 can adjust the correct levels of the different channels.

The adaptive matrix block 6 is the nucleus of the decoder, and at the same time the fact distinguishing it from a passive decoder. The block comprises two main sections: the adaptive logic, and a matrix comprising voltage controlled amplifiers VCA which improve the channel separation. The adaptive block continuously monitors the Rt and Lt sound channels at its input and from these it in a known way calculates sums and differences of the sound channels utilizing the signal level ratios of the R and L channels and C and S channels. So it examines in which direction the momentary dominance of the sound field is located. To determine this each main signal (L, R, C, S) is first full-wave rectified, the obtained DC voltages are logarithmically transformed in pairs, and then their differences are formed. This produces two independent control signals, one representing the dominance on the left-right axis, and the other on the center-surround axis. The control signals are further processed in the adaptation section of block 6 so that a set of control voltages (16 voltages) are obtained and supplied to the amplifier section of block 6, the amplifier section thus comprising a matrix of several voltage controlled amplifiers (VCA). The VCA matrix also receives as input signals the received signals left Lt and Rt. Control voltages control the amplification of the VCA am-

plifier, and then the matrix produces as outputs the signals R, L, C and S containing the direction information, which is amplified in the dominance direction and proportional to them as calculated by the adaptation block. Then, in the same way as in a passive Dolby decoder, the L, R and C signals are supplied to the main level controller 12 which also receives S through the side branch, as shown in figure 1.

However, this known Dolby Prologic decoder has some disadvantages, particularly in television applications. More and more television receivers are provided with Dolby Surround Sound decoders. As said above, after the encoder there are four audio channels, L R, C and S, which are available for any further processing of the audio signal arranged by the television manufacturer. Thus the further processing must be made separately for each audio channel, which leads to very expensive practical realizations. The object of the invention is to create an arrangement to minimize the effort of the further processing.

This is realized so that in the adaptive Prologic matrix a block performing linear signal processing operations in front of the matrix block of the VCA amplifiers, but regarding the input signal lines Rt and Lt after that point, from which the input signals are supplied to the adaptation block, in the same way as in the prior art encoder. But they are not supplied directly to the VCA matrix block, as in the prior art encoder, but first to a signal processing block performing linear operations (DSP), where the signals are processed. At the output of the DSP block there are processed R and L signals, which then are supplied to the VCA matrix block. In this way there are only two signals to be processed instead of four, but still the processing results are obtained in all four output channels of the decoder. The invention is particularly suitable to be used when all four channels are processed in the same way, e.g. filtered.

After the dematrix process the surround channel is processed by Dolby B decoding, as illustrated in figure 1. This is a non-linear operation producing an effect which changes as the signal value changes. Because the signal processing block of the invention changes the value of the surround signal, it can not be supplied to the Dolby B decoder. Therefore, in the application according to the proposed solution, the level of the surround signal is detected before the linear DSP block, and this information is used to control the Dolby B process, whereby the linear operations in block DSP do not anymore have an adverse effect on the operation of the Dolby B block.

The invention is described with the aid of the enclosed drawings, in which

figure 1 shows the block diagram of the known Prologic decoder, and

figure 2 shows how the DSP block according to the invention is located in the decoder of figure 1.

The structure of figure 1 was already described above. Figure 2 shows the adaptation and VCA amplifier matrix block 6 of figure 1, to which a linear signal processing block 23 of the invention is added. The input signals to the prior art block 6 (figure 1) are the sound channel signals right Rt and Lt, into which the center channel C and the surround S channel are encoded (figure 2). In prior art the encoded input signals would be connected both to the Dolby Prologic adaptation block, which determines the direction having the momentary dominating signal, and to the amplifier block, which comprises a matrix of voltage controlled amplifiers VCA. The adaptation block forms control signals controlling the gain of each VCA amplifier. At the output of the matrix we obtain four audio channels R, L, C and S.

According to the invention we place a block 23 performing linear signal processing operations after that point, from which the left channel Lt and the right channel Rt are branched to the adaptation block, but before the channel input to the VCA matrix block. The block 23 contains at least one digital signal processor DSP.

On the audio signals of the left channel and the right channel the DSP block 23 can perform desired operations, such as filtering, equalization and so on. The desired operations can be selected for each application and can be freely determined by the television manufacturer. Because there are only two channels to be processed we need only two filters and not four, as the case would be, if the audio signals would be processed after the Dolby encoder.

The processed signals of the left and right channels are connected from the DSP block to the VCA amplifier block 22, which then in a known way generates the four audio channels.

The surround signal obtained from the amplifier block 22 can not be supplied to a non-linear Dolby B decoder, because the DSP block 22 has changed the value of the surround signal. Therefore the input signals are connected also to the surround signal level detector 24. The detected surround signal is now a surround "correctly" encoded into the input signals, so that this signal is connected to the Dolby B decoder. This decoder now operates properly.

The invention has several advantages compared to audio signal processing after the decoder. First of all there are only two channels (Lt, Rt) to be processed, and still this has an effect on all four output channels of the decoder. In the second

place there is a smaller need for equipment when the processing is made in hardware, or less signal processor code is required when the arrangement is realized in software. In the third place the processing of two channels does not require as much processing power as the processing of four channels. The linear processing made according to the invention does not interfere with the function of the Dolby decoder itself.

Claims

1. Decoder, which receives a two channel audio signal (Lt, Rt) and decodes it into a four channel audio signal (left, right, center, surround), and having a Dolby Prologic adaptive matrix block (6) comprising
   - a matrix section (22) formed by voltage controlled amplifiers (VCA), whose amplifiers are individually controlled by amplifier gain control signals, and whose output signal is a four channel audio signal (L, R, C, S),
   - an adaptation section (21), having as input signal the two channel audio signal (Lt, Rt) and as output signals said control signals for the amplifier gains, whereby the decoder further comprises a Dolby B decoder section to process the surround signal detected from the two channel audio signal,

   characterized in that the two channel audio signal (Lt, Rt) is supplied to a block (23) performing linear signal processing operations and processing separately the signals of both channels, and that the two channel output signal (L't, R't) of said block is the input signal of the matrix section (22).

2. The decoder of claim 1, **characterized** in that the two channel audio signal (Lt, Rt) is also supplied to the surround signal detector (24), which detects the surround signal (S) encoded into the input signals (Lt, Rt), whereby the output signal of the detector is the input signal of the Dolby B decoder section.

3. The decoder of claim 1, **characterized** in that the block (23) performing signal processing is a digital signal processor.

4. The decoder of claim 1 or 3, **characterized** in that the linear operation is filtering.

5. The decoder of claim 1 or 3, **characterized** in that the linear operation is equalization.

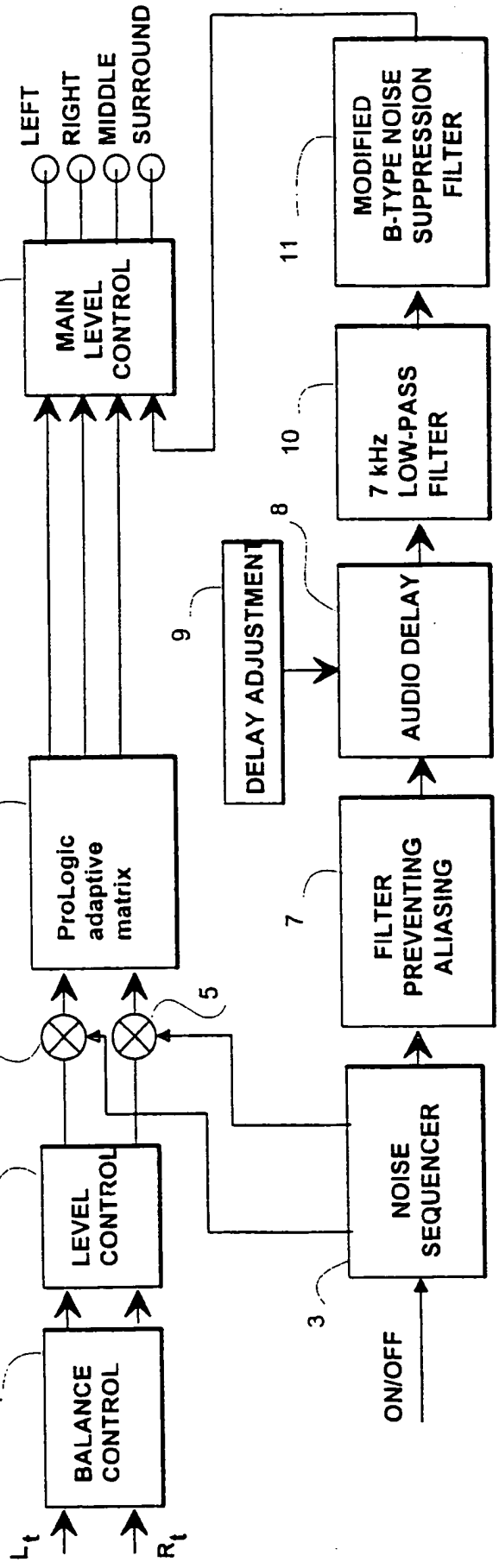
L_t
R_t
BALANCE CONTROL
1
LEVEL CONTROL
2
NOISE SEQUENCER
3
ON/OFF
4
5
ProLogic adaptive matrix
6
FILTER PREVENTING ALIASING
7
DELAY ADJUSTMENT
9
AUDIO DELAY
8
7 kHz LOW-PASS FILTER
10
MODIFIED B-TYPE NOISE SUPPRESSION FILTER
11
MAIN LEVEL CONTROL
12
LEFT
RIGHT
MIDDLE
SURROUND

Fig. 1

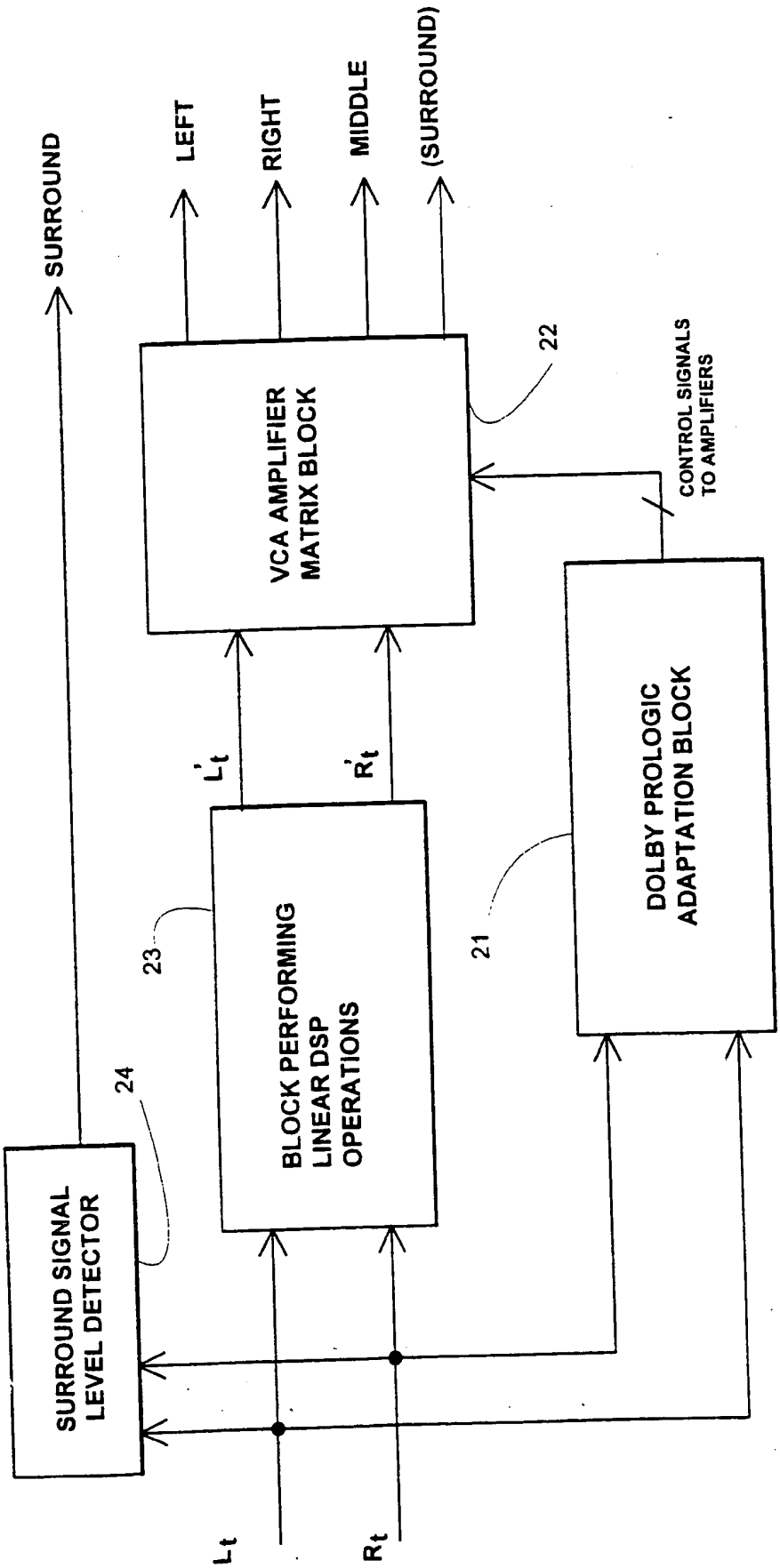
SURROUND
LEFT
RIGHT
MIDDLE
(SURROUND)
VCA AMPLIFIER MATRIX BLOCK
22
CONTROL SIGNALS TO AMPLIFIERS
DOLBY PROLOGIC ADAPTATION BLOCK
21
BLOCK PERFORMING LINEAR DSP OPERATIONS
23
L_t'
R_t'
SURROUND SIGNAL LEVEL DETECTOR
24
L_t
R_t

Fig. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

DOCUMENTS CONSIDERED TO BE RELEVANT

EP 94108673.8

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP - A - 0 483 950 (PIONEER ELECTRONIC) * Fig. 2; column 3, line 18 - column 4, line 23 * --	1	H 04 S 3/00
A	US - A - 4 799 260 (MANDELL) * Fig. 1; abstract * --	1	
A	GB - A - 2 154 835 (KINTEK) * Fig. 2; abstract * ----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H 04 S
H 04 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	02-09-1994	DRÖSCHER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

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